

AD-A268 249



FASTC-ID(RS)T-0729-92

2 R.L.

FOREIGN AEROSPACE SCIENCE AND TECHNOLOGY CENTER



THREE SHORT ARTICLES FROM JAPANESE "LASER JOURNAL"



DTIC
ELECTE
AUG 16 1993
S E D

93-18668



1785

Approved for public release;
Distribution unlimited.



93

285

HUMAN TRANSLATION

FASTC-ID(RS)T-0729-92 23 July 1993

MICROFICHE NR: 93C000477

THREE SHORT ARTICLES FROM JAPANESE "LASER JOURNAL"

English pages: 12

Source: Jiguang Zashi, Vol. 8, Nr. 3, 1981, pp. 47-49

Country of origin: China

Translated by: SCITRAN

F33657-84-D-0165

Requester: FASTC/TATD/Dr. Newton

Approved for public release; Distribution unlimited.

Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input checked="" type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

DTIC QUALITY INSPECTED 3

THIS TRANSLATION IS A RENDITION OF THE ORIGINAL FOREIGN TEXT WITHOUT ANY ANALYTICAL OR EDITORIAL COMMENT STATEMENTS OR THEORIES ADVOCATED OR IMPLIED ARE THOSE OF THE SOURCE AND DO NOT NECESSARILY REFLECT THE POSITION OR OPINION OF THE FOREIGN AEROSPACE SCIENCE AND TECHNOLOGY CENTER.

PREPARED BY:

TRANSLATION DIVISION
FOREIGN AEROSPACE SCIENCE AND
TECHNOLOGY CENTER
WPAFB, OHIO

TABLE OF CONTENTS

Graphics Disclaimer	ii
TEA CO ₂ In-Cavity Prism Modulated Laser Device	1
Preliminary Experimental Study of CO Electrically Excited Gasdynamic Laser	4
A Hollow Cathode Limiting Discharging He-Ne Laser	10

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

(FASTC-ID(RS)T-0729-92)

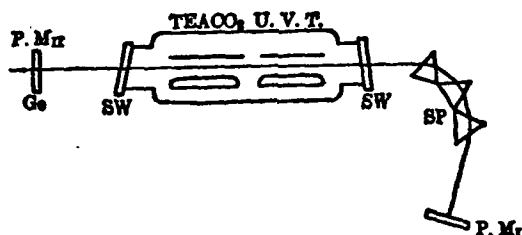
TEA CO₂ In-Cavity Prism Modulated Laser Device

Abstract: A branch-selected oscillation of a pulsed TEA CO₂ laser with three NaCl prisms placed in the cavity as dispersive elements is reported. 60 laser lines have been obtained.

A two-stage synchronous ultraviolet pre-ionization pulsed TEA CO₂ laser device was used. Pre-ionization was accomplished by the surface sparking of the stainless steel array. Main discharger and pre-ionizer both had their individual power supply and the time delay was controlled by controllable time-delay trigger. To obtain the steady and homogeneous arc-free discharging, propylamine of low ionization was used as the seed gas. Discharging volume was $7 \times 7 \times 100 \text{ cm}^3$. The main-discharging energy-saving capacitor for the main discharging circuit (for each stage) was $0.047 \mu\text{F}$ and the capacitor for pre-ionization circuit was $0.07 \mu\text{F}$. To ensure long-term arc-free operation and to ensure smooth modulation, the proportion of the working gas was chosen as: CO₂ : N₂ : He = 3 : 2 : 6. Total gas pressure was 560 torr and input power was controlled to be within 100 J/l. Time delay between main discharging and pre-ionization was selected to be 1 μsec . The device was operated in single-pulse mode with about 3-4 pulses/min.

The laser oscillation cavity was parallel surface cavity. One end of the cavity was a gold plated total reflection mirror and the other end was plane germanium output mirror without

plating. The cavity was 2.5m in length. Three NaCl prisms were placed in the cavity as dispersive elements. The apex angles of the three prisms were 56, 66, and 67 degrees. The three NaCl prisms were placed in the cavity so that the light ray of $10.6\mu\text{m}$ wavelength would enter the prism with the least deviation angle and the light ray would be transmitted in the cavity parallel to the base plane of the prisms. Through the three prisms the light ray would be deviated 62.5 degrees. As shown in the figure, the arrangement of the prisms could be easily adjusted by He-Ne laser and the Brust angle deviation was not significant, therefore, the loss within the cavity could be minimized.



- key:
- pulsed TEA CO_2 in-cavity prism-modulated laser
 - U.V.T.-two stage synchronous ultraviolet pre-ionization TEA CO_2 laser; SW-NaCl window; SP-NaCl prism; P.M_1 -gold plated total-reflection mirror; P.M_2 -germanium plane output mirror

Rotating the total reflection mirror, the spectrum lines scattered by the prisms would slowly become parallel to the plane cavity and would acquire high gain and resulted in oscillation.

When the total reflection mirror was turned $3^{\circ}23'$, the P and R branches of CO_2 $10.4\mu\text{m}$ ray and the P and R branches of $9.4\mu\text{m}$ ray would be obtained, coupling would occur. Therefore, the branch-selected oscillation of pulsed TEA CO_2 laser was achieved. Using a 1m light grate spectrometer (light grate 100×100 lines/mm, sparking wavelength $11.5\mu\text{m}$) and He-Ne 6328A targeting infrared marker, the CO_2 laser wavelength could be measured and 60 oscillation lines were obtained. Also, the relative energy output of various laser lines was measured directly against the output lines. When the discharging area was $5\times 2.5\times 100\text{cm}$, $\text{CO}_2:\text{N}_2:\text{He}=3:2:5$, and total gas pressure 660 torr, the output energy for $104\mu\text{m}$ P(18) branch was 7.5J/pulse and the peak power was 75MW.

(Chinese Science Academy, Shanghai Optoelectronic Institute
Yu, Shu-Shen; Du, Long-Long; Ding, Ai-Jen; and Lo, Chi-Hong.
Manuscript received on May 29, 1980.)

Preliminary Experimental Study of CO Electrically Excited Gasdynamic Laser

Abstract: An electron-beam preionized, electrically excited gasdynamic CO laser was developed. Preliminary experimental research on its performance has been made.

The dynamic mechanism which played the major role in CO laser is: CO molecules, excited by electron beam, pass through fast VVT exchange collision and constitute the non-Boltzman distribution with high vibration energy so that partial reverse is formed among certain vibration energy levels. Analysis has shown [1] that the stable particle number n_v for vibration energy level v is

$$n_v = n_0 \exp\left(-\frac{vE_1}{k\theta_1}\right) \exp\left(\frac{vE_1 - E_v}{kT_g}\right)$$

where n_0 is the particle density of the base energy state, E_1 and E_v are the energies of vibration levels 1 and v , respectively, θ_1 is the characteristic temperature of vibration level 1, T_g is the average gas dynamic temperature. From the above equation, it can be shown that in order to increase n_v (and inverse), the gas temperature T_g should be decreased or θ_1 should be increased (or the input energy should be increased).

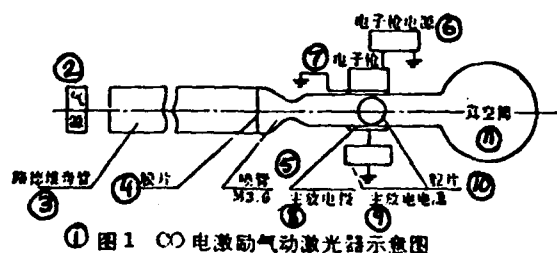
By adopting the technique to make the gas travel in supersonic speed, the temperature T_g was reduced to about 60K.

Then the electron beam preionization was used to control main discharge and excite cold gas flow to output laser.

1. Description of equipment setup

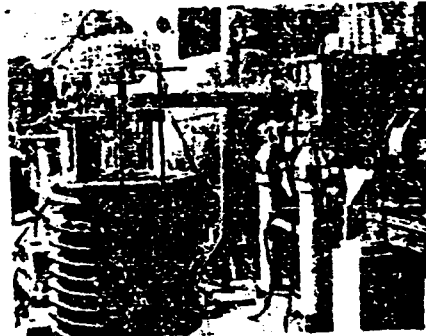
The basic equipment setup, including a M3.6 supersonic wind tunnel, a 150kV electronic bridge system, a 2kV main discharging system and an optical system, is shown in figures 1 and 2. The working principle was to use the electron beam preionization and the high speed freezing gas current emitted from the wind tunnel nozzle to generate the main discharging gas molecules and to obtain laser oscillation through laser cavity. [2.,3]

Wind Tunnel: The stagnant section is a 5m long Ludwig pipe filled with the typical working gas CO:Ar=5:95 with 4.4atm pressure. When the Mach number was 3.6, a stable current of 0.06atm, 60K temperature, and 15 μ sec duration can be obtained in a two-dimensional supersonic nozzle. [4] A thermal cathode electronic gun equipped with a 0.1 μ F(150kV) capacitor can excite 2.4 liters of gas. However, in this preliminary study, only 1/5 of the output laser was used and the main discharging was powered by 900 μ F capacitor set with 2kV charging capacity. The optical, mechanical, and electronic systems were coordinated by a synchronous control device.



key: 1 - Figure 1: Illustration of CO electron beam excited
gas dynamic laser

- 2 - gas source
- 3 - Ludwig pipe
- 4 - diaphragm
- 5 - nozzle
- 6 - electron beam source
- 7 - electron beam gun
- 8 - main discharging
- 9 - main discharging power supply
- 10 - cavity film
- 11 - vacuum chamber



- key: - Figure 2: Equipment set up picture
- Ludwig pipe was at the right; upper right hand corner is the electron beam gun; below the electron beam is the cavity region; the foreground on the left is the power supply for electron beam gun filament; and the background on the left is the vacuum system for the electron beam gun; the background in the center is the vacuum chamber.

2. Adjustment and Preliminary Experimental Results

The stagnant pressure and cavity pressure, measured with piezoelectric ceramic energy converter, were used to adjust the performance of the wind tunnel to design requirement. The voltage waveform of the electron gun, measured with pressure partition device, and the total current input of the cavity, measured with the mutual induction coil, were used to adjust the performance of the electron gun so that the maximum achievable current was 480uA, which was reduced to zero in about 1μsec.

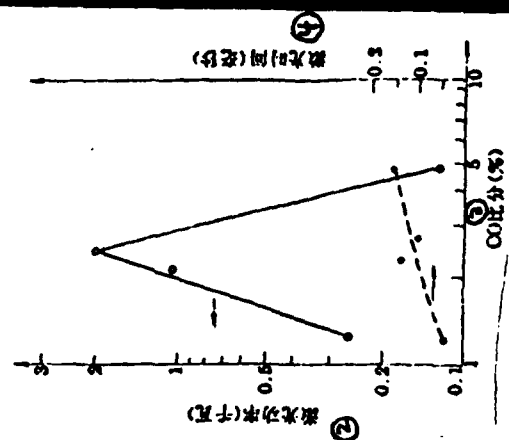
Maintaining these basic wind tunnel and electron gun parameters, a series of experiment was carried out by changing the gas ratio, main discharging voltage, and optical cavity parameters. When a gas mixture CO/Ar/N₂ = 2.5/72.5/25 was used a laser output of 80μJ (time duration 0.2μsec and average power 400W) was obtained. The preliminary result of the parametric study was: 1) effect of gas mixture: The output power was increased from 400W to 2kW when the CO gas of very low purity (CO/CO₂/N₂ = 93.6/1.4/1) was purified with liquid nitrogen (CO₂ content was reduced to 0.3%). A series of repeated tests showed that using purer CO gas the output power can be increased by about half a magnitude. This is because the Fe(CO)₅ and CO₂ in the gas mixture will significantly reduce the laser output.[2] The change in output laser power as a function of CO ratio is shown in figure 3. It is clear that the output laser power was at its maximum when CO content was 2.5%, which was probably due to the fact that CO was not in the high purity range (such as

ppm). [2] and the effect of harmful impurities increased as CO was increased. The combination of these two contradictory effects resulted in the appearance of a peak. Besides, we have also found out that when N_2 content was increased from 25% to 47%, time duration of laser was increased from 0.1 μ sec to 0.2 μ sec and the power was increased from 140 μ W to 170 μ W. Moreover, when N_2 was not added and Ar content was increased from 72.5% to about 95-98%, no laser output could be found upon discharging (even though arc was generated). In addition, 1% H_2 was added to the gas mixture and no significant effect on the laser output was observed.

2) effect of discharging parameters: When the main discharging voltage was increased to 2.4kV, the arc was generated very quickly while the laser output was relatively weak (about 12.5 μ J, or 250W). Also, the electrodes were intentionally reversed (the lower electrode was changed to cathode) and the voltage-current waveform was found smoother and an output of 1400W was obtained when the gas mixture was CO/Ar/ N_2 =2.5/72.5/25.

3) effect of gas pressure: The pressure of the stagnant gas pressure section was reduced to 3atm and the output laser power was somewhat lowered, but not significantly.

4) effect of optical cavity: The ϕ 4mm output coupling hole was changed to ϕ 8 and output laser power was reduced to about one-half, indicating that the gain was still very low.



- Figure 3: Variation in laser output with change in CO ratio

key: 2 - Laser power (kW)
 3 - CO ratio (%)
 4 - Laser duration time (μ S)

References

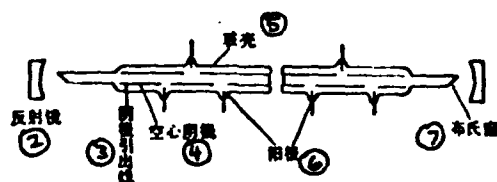
- [1] W. B. Lacina: AD-729235
- [2] R. E. Center: "High-power, efficient electrically-excited CO lasers", in "Laser Handbook", 3, editors M. L. Stitch, North-Holland, 1979
- [3] J. G. Jones et al.: AIAA 74-562
- [4] Cheng Chu: "Lasers", 1978, 5, No. 5-6, 52
 (Chinese Science Academy, Shanghai Optoelectronic Institute, Electromagnetic excited gas dynamic laser device research group. Manuscript received on May 27, 1980.)

A Hollow Cathode Limiting Discharging He-Ne Laser

Abstract: The discharging behavior of flute-type hollow cathode in limited discharge is investigated. He-Ne laser output at 6328Å is obtained at limited discharge. It is about 10 times higher than that in ordinary hollow cathode discharge.

Hollow cathode discharging is a new excitation technique. Discharge is possible with low voltage and the excited section is the cathode potential drop section and negative luminance section of the hollow cathode. Because high energy electrons exist in these sections and He atom can be excited to create many metastable states, He-Ne laser can also be obtained.[1,2] In this report, hollow cathode discharge under the condition of low pressure with external excitation was reported and the power of output laser can be increased by a few times.

A flute-type hollow cathode was used. The flute was oxygen-free copper tube with inner diameter of 4mm and length of 55cm. A hole was opened every 5cm along the tube and anodes were placed at these holes. Altogether there were 10 anodes as figure 1 shows.

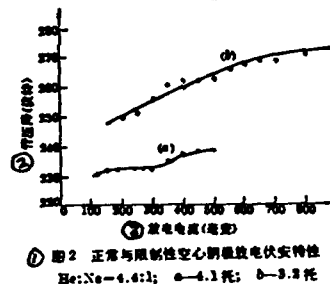


① 图1 空心阴极氦-氖激光器结构

key: 1 - Figure 1: Hollow cathode limiting He-Ne laser

- 2 - reflecting mirror
- 3 - cathode extruding wire
- 4 - hollow cathode
- 5 - glass container
- 6 - anode
- 7 - output window

Figure 2 shows the voltage-ampere characteristic curve. The pressure for curve a was higher, $PD > 14$ torr-mm, and was normal discharge and cathode potential drop did not change significantly with current. The pressure for curve b was lower, $PD < 14$ torr-mm, and maximum discharge current increased by many folds, cathode potential drop also increased proportionally.

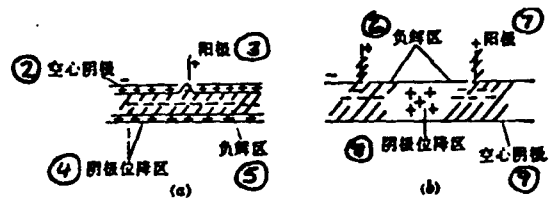


key: 1 - Figure 1: Hollow cathode discharge voltage-ampere characteristics, He:Ne=4:4.1; a-4.1torr, b-3.2torr

- 2 - pipe potential drop
- 3 - discharging current (mA)

The major difference between the cathode discharge of the two hollow cathodes was the structure of the cathode potential drop section. In ordinary hollow cathodes, the thickness of the

cathode potential drop section was smaller than the radius of the hollow cathode tube and a negative luminance section existed on the axis of the tube as figure 3(a) shows. Because the thickness of the potential drop section and the length of the negative luminance section were both inversely proportional to the gas pressure, under the condition of low gas pressure, the thickness of the cathode potential drop section already exceeded the radius of the hollow cathode tube and the cathode potential drop section could not be confined along the longitudinal direction and spread across the axial direction and was called the limited discharge of hollow cathode; as figure 3(b) shows. In this case, the negative luminance section also spreaded more widely.



key: 1 - Figure 3: Discharging structure of two hollow cathodes

- 2 - hollow cathode
- 3 - anode
- 4 - cathode potential drop region
- 5 - negative luminance region
- 6 - negative luminance region
- 7 - anode
- 8 - cathode potential drop region
- 9 - hollow cathode

DISTRIBUTION LIST

DISTRIBUTION DIRECT TO RECIPIENT

<u>ORGANIZATION</u>	<u>MICROFICHE</u>
B085 DIA/RTS-2FI	1
C509 BALLOC509 BALLISTIC RES LAB	1
C510 R&T LABS/AVEADCOM	1
C513 ARRADCOM	1
C535 AVRADCOM/TSARCOM	1
C539 TRASANA	1
Q592 FSTC	4
Q619 MSIC REDSTONE	1
Q008 NTIC	1
Q043 AFMIC-IS	1
E051 HQ USAF/INET	1
E404 AEDC/DOF	1
E408 AFWL	1
E410 ASDTC/IN	1
E411 ASD/FTD/TTIA	1
E429 SD/IND	1
P005 DOE/ISA/DDI	1
P050 CIA/OCR/ADD/SD	2
1051 AFTT/LDE	1
P090 NSA/CDB	1
2206 FSL	1

Microfiche Nbr: FTD93C000477
FTD-ID(RS)T-0729-92